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Design and Validation of the Fractal Model of Virtual Curriculum with an Intercultural Approach (Case Study: Islamic Azad University Branches in Mazandaran)

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A B S T R A C T

Purpose: This study aimed to design and validate the Fractal Model of Virtual Curriculum with an Intercultural Approach in the context of Islamic Azad University branches in Mazandaran.

Methods and Materials: The research employed a mixed-methods approach consisting of qualitative and quantitative phases. In the qualitative phase, data were collected through semi-structured interviews with 16 experts in curriculum studies, online education, and intercultural knowledge, using snowball sampling. Data analysis followed inductive content analysis, including open, axial, and selective coding. In the quantitative phase, a 92-item questionnaire was developed based on the qualitative findings and administered to 250 undergraduate, master's, and doctoral students in educational sciences at Islamic Azad University, selected through stratified random sampling. Data analysis was conducted using structural equation modeling (SEM) in SMART-PLS, with validation performed through exploratory and confirmatory factor analysis.

Findings: The validated model consisted of nine elements: objective, content, learning activities, teaching-learning strategies, space, time, grouping, educational materials, and evaluation, with 23 subcomponents. Path analysis showed that all relationships between elements were statistically significant ($p < 0.001$). The strongest relationships were observed between learning activities and collaborative activities ($\beta = 0.900$), time and instructional time suitability ($\beta = 0.932$), and grouping and multicultural teams ($\beta = 0.890$). The KMO values for all elements confirmed sampling adequacy, and Bartlett's test indicated the feasibility of factor analysis.

Conclusion: The findings emphasize the need for inclusive educational strategies, flexible digital learning environments, and multicultural assessment methods to enhance the effectiveness and equity of online curricula in higher education.

Keywords: *curriculum, virtual curriculum, fractal, intercultural.*

1. Introduction

In the virtual education system, both instructors and students are stakeholders, and the success and effectiveness of this system depend on its effective utilization by both groups. However, it is predominantly student-centered. On the other hand, the e-learning system has provided flexibility for instructors in terms of location, time, and instructional pace (Bezi et al., 2024; Delghandi et al., 2024). Virtual education generally refers to the use of electronic systems such as computers, the Internet, electronic storage devices, electronic journals, virtual newsletters, and similar technologies aimed at reducing commuting, saving time and costs, and simultaneously improving and simplifying education (Por Jafari shir Joposht et al., 2024; Shariati et al., 2024). There are various systems classified as virtual education that facilitate distance learning, but the primary concern is that individuals should be aware of the types of systems available, make the correct selection, and use them properly. These systems can sometimes replace in-person classes. At the same time, for diligent and motivated learners, they can serve as a complement to books and classroom learning. In summary, virtual education brings education to the people instead of bringing people to education (Ghanbari et al., 2019).

The curriculum in higher education encompasses multiple layers and diverse dimensions, covering a vast scope. In recent years, higher education has faced numerous changes in various areas. Increased competition, diversity among students, growing industrial demands, budget reductions, and rapid technological advancements (Lisa et al., 2016), shifts from centralized to transnational education systems (Organization for Labor, Education, and Employment, 2015), and changes in teaching methods are among the most significant transformations. The nature of such educational changes heavily depends on how the learning environment is perceived, academic background, and various cultural and social factors (Bikbulatovaa et al., 2016), as well as the role of faculty members, students, and specialized educational staff in structuring university curricula (Sabouri et al., 2020). Curriculum design serves as a conceptual map for curriculum developers and is considered one of the fundamental aspects of curriculum studies. It involves determining resources, identifying curriculum components, and making decisions regarding each element (Ornstein & Hunkinks, 2018).

The multicultural education movement plays a significant role in providing equal educational opportunities for all individuals and contributes significantly to the globalization of nations. It plays an effective role on the international stage, engaging with various cultures. The fundamental goal of the multicultural approach in curriculum development is to promote a peaceful lifestyle and sustainable coexistence among individuals and groups. Society comprises diverse groups affiliated with different cultural domains. To ensure unity, coherence, and integrity within society, every individual should have equal opportunities, making this issue a necessity in the realm of education (Aini et al., 2018).

Fractals are forms that, unlike Euclidean geometric shapes, are not conventionally regular. At first glance, these shapes appear entirely irregular, but upon closer examination, their degree of irregularity remains consistent across all scales, implying a different form of order. A fractal object appears the same from both near and far. Given the characteristics of virtual environments and learner-centered theories, the structuring of virtual curriculum elements and their interrelations—including virtual curriculum objectives, content preparation and organization, activity design, learning materials and resources, teaching methods, and evaluation—constitutes what is known as virtual curriculum design (Shamshirgaran & Afkari Fereshteh, 2019). One of the most essential characteristics of fractals is their self-similarity, meaning that fractals are composed of parts that resemble the whole, where complex forms are generated through the repetition of simpler forms. While curricula do not consist of infinite components, curriculum planners aim to incorporate as many details and components as possible. Although this characteristic does not precisely align with fractal geometry due to limitations, the emphasis on intricate details in curriculum innovations justifies its association (Shahbazi, 2020; Shahbazi et al., 2020a, 2020b).

Formal education, due to its connection with social culture and its influence on goal-setting and curriculum content formulation, cannot be detached from society. On the other hand, learning experiences based on cultural characteristics of individuals and groups tend to be more successful (Shahab Lavasani et al., 2020). Multicultural curricula and education serve as prerequisites for genuine transformation in human societies, which occurs in three fundamental dimensions: self-transformation, school transformation, and societal transformation. This approach seeks to integrate diverse cultures into students' real-life experiences (Mostafaei & Hosseini, 2021).

No culture should adopt a policy of isolative loss in education. The content of curricula should be explored in search of cultural indicators to gain a comprehensive

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understanding of each culture and enhance intercultural communication. The crucial question remains: How is an intercultural curriculum established, and to what extent does this endeavor entail a transformation in the perspective of higher education in Iran? This perspective shift inevitably leads curriculum studies specialists not only to pursue a comprehensive understanding of cultural differences but also to recognize that, despite these differences, humans share more similarities across cultures than disparities (Shahbazi, 2020; Shahbazi et al., 2020a). Cultural and racial differences among students often result in fundamental differences in their thinking, worldview approaches, and cultural perspectives, leading to potential challenges. If a university aims to mitigate the impact of cultural differences on students' academic interactions with faculty and staff, it must first acknowledge the reality of these differences and recognize their potential to create significant challenges in higher education (Shahbazi, 2020; Shahbazi et al., 2020a, 2020b).

In a study conducted by Warren et al. (2021) on the development of virtual curricula in Southeast Asia, findings indicated that the primary obstacle reported by practitioners in delivering radiotherapy training was inadequate education. There was both a significant need and a strong interest in virtual education, particularly in head and neck contouring, which was currently perceived as time-consuming and inconsistent across practices (Warren et al., 2021). Similarly, Arruza and Chau (2021) investigated the effectiveness of cultural competence education in enhancing knowledge acquisition, performance, attitudes, and student satisfaction in health sciences. Their results showed that while various approaches to cultural education exist in terms of method, frequency, and duration of interventions, students who experienced cultural education interventions scored higher on post-tests compared to their baseline cultural knowledge. However, there was no significant difference between their scores and those of students who did not receive the intervention (Arruzza & Chau, 2021). In a study by De Hei et al. (2019) on developing intercultural competence through collaborative learning in international higher education, researchers demonstrated that collaborative learning enhances intercultural competence within international higher education contexts (De Hei et al., 2019).

From the researcher's perspective, a systematic study of culture by curriculum specialists necessitates greater emphasis on the field of intercultural curriculum studies in Iran. Intercultural curriculum theory examines how cultural components influence curriculum design and how higher education integrates key cultural variables into its curriculum planning system. The content of curricula should be continually reviewed and revised to align with societal needs and the latest scientific advancements globally, thereby fostering talent development, attitudinal growth, and value promotion. Interculturalizing the curriculum in Iran can foster an intercultural, flexible, and dynamic identity—an aspect often overlooked in higher education. Given the increasing integration of virtual education and intercultural curriculum models, the question arises: What is the structure of the fractal virtual curriculum model with an intercultural approach in the Islamic Azad University branches in Mazandaran?

2. Methods and Materials

This study is an applied research in terms of purpose and employs a mixed-method approach combining qualitative and quantitative methods. In the qualitative phase, inductive content analysis was used to analyze the data, while in the quantitative phase, deductive analysis was conducted using structural equation modeling techniques.

In the qualitative stage, experts and specialists were consulted to ensure the validity of the interviews. The statistical population for qualitative analysis included curriculum specialists with sufficient expertise and experience, as well as those who had published articles, books, or research projects in the fields of online teaching, globalization of culture, internationalization of curricula, intercultural knowledge, virtual education, virtual classrooms, and intercultural knowledge.

The selection criteria for experts included having academic qualifications related to curriculum models, virtual education, intercultural approaches, and global classrooms, as well as having published research, books, or projects on the subject under study. To select the sample for content analysis of the interviews, the "snowball sampling" method was used. This technique is particularly useful for collecting samples that are otherwise difficult to obtain, as it relies on social networks and referrals from individuals with shared characteristics. The researcher initially identified a small group of qualified participants and asked them to refer others with similar expertise. Ultimately, 16 experts were selected using this technique until theoretical saturation was reached. The researcher encountered data saturation after the thirteenth interview but continued until the sixteenth participant to ensure the adequacy of the collected data.

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Semi-structured interviews were used as the primary data collection instrument. To determine the validity and reliability of the qualitative phase, necessary evaluations were conducted, including acceptability (expert review), confirmability (expert validation), and intra-topic agreement. For validity assessment, the transcribed text of the first five interviews, along with the initial coding based on these interviews, was provided to the interviewed experts for review. They were asked to comment on the interpretations and conclusions drawn by the interviewer. In case of discrepancies or necessary revisions, modifications were made to align the analysis with the experts' perspectives. For reliability assessment, the final categories were returned to several initial participants for review and approval, incorporating their suggested modifications.

For intra-topic agreement, two coders (evaluators) were recruited from among the experts to participate in the study as research collaborators (coders). They were trained in the necessary coding techniques and procedures. In each interview, codes that were identical between the two coders were marked as agreements, while differing codes were labeled as disagreements. This process was used to assess the accuracy and reliability of the research.

Given the study's objectives, qualitative content analysis was used to analyze the transcribed expert interviews. There are similarities and differences between different qualitative analysis methods. Despite certain similarities between content analysis and other qualitative methods such as thematic analysis and grounded theory, the key distinction of the present study’s method lies in its ability to integrate quantitative analysis through various statistical tests alongside qualitative data analysis. The data analysis consisted of three types of coding: (1) open coding (initial), (2) axial coding, and (3) selective coding.

Open coding (initial coding) is an analytical process through which concepts are identified, and their characteristics and dimensions are discovered within the data. During open coding, data are broken down into distinct segments, carefully examined to identify similarities and differences, and questions are formulated about the phenomena reflected in the data.

Axial coding is the process of linking categories to their subcategories and establishing connections between categories at the level of characteristics and dimensions.

Selective coding involves integrating and refining the categories identified during axial coding, leading to an overall analysis of the data.

The statistical population for the quantitative phase was determined as follows: undergraduate, master's, and doctoral students in educational sciences at the Islamic Azad University branches in Mazandaran, covering 14 university branches between 2021 and 2023. The sampling method for the quantitative phase was stratified proportional sampling, where each of the three regions—western, eastern, and central Mazandaran—was considered a separate stratum. In terms of sample size, factor analysis generally benefits from larger samples. Studies have shown that correlations among variables fluctuate more in smaller samples compared to larger groups. There is no consensus among scholars on the minimum sample size required for factor analysis. For example, Kline (2010) suggests that for exploratory factor analysis, 10 to 20 samples per variable are necessary, while a minimum sample size of 200 is considered defensible. Ultimately, a sample of 250 participants was deemed appropriate and scientifically justifiable.

In the quantitative phase, the data collection instrument was a 92-item questionnaire derived from the conceptual model established in the qualitative phase. The identified variables in the conceptual model were quantitatively measured to obtain responses from the sample, essentially testing the qualitative research model. To determine the validity and reliability of the qualitative phase’s instrument, necessary evaluations were conducted, including acceptability (expert review), confirmability (expert validation), and intra-topic agreement. In the quantitative phase, questionnaire validity was confirmed using three methods: face validity, content validity (CVI ranging from 0.9 to 1, CVR ranging from 0.6 to 0.9), and construct validity (convergent validity ranging from 0.552 to 0.713, and discriminant validity exceeding the correlation of the construct with other constructs). Reliability was confirmed using three methods: factor loading coefficients (greater than 0.4), Cronbach’s alpha (ranging from 0.727 to 0.816), and composite reliability (ranging from 0.800 to 0.882).

For data analysis, three-stage coding was performed in the qualitative section using Atlas software. In the quantitative section, exploratory and confirmatory factor analysis and path analysis were conducted using SPSS and Smart PLS software.

3. Findings and Results

The primary focus of this study was to explore and identify the influencing factors related to the concept, subcategories, and criteria of the "Fractal Model of Virtual

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Curriculum with an Intercultural Approach in the Islamic Azad University Branches of Mazandaran" as the core concept. To achieve this, the core category, subcategories, and indicators were identified through initial, axial, and selective coding of the data obtained from in-depth and exploratory interviews with key experts, followed by refining the conceptual codes.

For the initial coding phase, data were examined at the sentence and phrase level for each interview, and conceptual codes were extracted from the interview transcripts. In the subsequent phase, refinement and reduction were applied, organizing the indicators into subcategories, which were then continuously reviewed and labeled. In the selective coding phase, the subcategories were further organized and labeled under core categories. To ensure the proper organization of each core and subcategory, the interview transcripts were reviewed again, and the indicators were examined to reach logical saturation for both the core and subcategories. The initial and axial coding process was discontinued once a meaningful classification was established after multiple reviews of the interview transcripts.

A. Objective Element

Step One: Initial Coding

During the open coding phase, 33 initial codes were identified. After reviewing and eliminating duplicate codes, 21 codes were removed, leaving 12 final codes categorized under subcategories.

Step Two: Axial Coding

The results of the subcategory classification for the "Objective" element are presented in the table below. The purpose of this stage was to establish relationships among the generated criteria.

Table 1

Results of Subcategory Classification for the Objective Element

Criterion	Subcategory	Code
[N1-1] Enhancing understanding and respect for cultural differences		
[N2-1] Encouraging student participation from diverse cultural backgrounds		
[N4-1] Encouraging students to reflect on the impact of cultural diversity on society	Cultural Cohesion	1
[N12-2] Developing essential skills for effective collaboration with individuals from different cultures		
[N5-1] Ensuring equal access to educational resources for all students		
[N10-1] Providing a supportive and equitable environment for students with special needs		
[N7-1] Teaching methods based on students' needs and abilities	Educational Equity	2
[N15-2] Reducing educational disparities among students from different cultural and economic backgrounds		
[N8-2] Encouraging research and learning about different customs		
[N14-2] Interactive activities for practicing intercultural communication skills		
[N16-2] Addressing issues related to living in multicultural societies, such as bias and discrimination	Understanding Multicultural Concepts	3
[N1-2] Identifying and understanding cultural differences among individuals		

Step Three: Selective Coding

The results of selective coding are presented in the table below. In this phase, 12 final codes categorized under 3 subcategories were integrated into 2 core categories.

Table 2

Classification of Core Categories, Subcategories, and Indicators for the Objective Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Cultural Interaction and Participation	2	Cultural Cohesion - Understanding Multicultural Concepts	8
2	Knowledge and Operational Aspects	1	Educational Equity	4

B. Content Element

Step One: Initial Coding

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During the open coding phase, 28 initial codes were identified. After reviewing and eliminating duplicate codes, 16 codes were removed, leaving 12 final codes categorized under subcategories.

Step Two: Axial Coding

The results of the subcategory classification for the "Content" element are presented in the table below. The purpose of this stage was to establish relationships among the generated criteria.

Table 3

Results of Subcategory Classification for the Content Element

Criterion	Subcategory	Code
[N1-3] Curriculum content includes resources from various cultures addressing cultural diversity and its richness		
[N2-3] Incorporates examples and stories from different cultures to explain multicultural concepts		
[N4-3] Promotes respect and sensitivity toward cultural differences, linguistic and religious diversity	Multicultural Content	1
[N3-3] Helps students understand challenges related to intercultural interactions		
[N5-3] Includes information about customs, languages, and traditions of various cultures		
[N13-4] Identifies and analyzes cultural issues such as discrimination, inequality, and bias		
[N10-4] Fosters respect for cultural differences and encourages its development	Multicultural Literacy	2
[N7-3] Encourages respect and acceptance of diverse cultures		
[N4-4] Activities and exercises to enhance intercultural communication skills and conflict resolution		
[N6-4] Raises cultural awareness and fosters a deeper understanding of different perspectives		
[N7-4] Strengthens students' ability to adapt to diverse cultural environments	Cultural Intelligence	3
[N16-3] Introduces various cultures, their histories, customs, and lifestyles		

Step Three: Selective Coding

The results of selective coding are presented in the table below. In this phase, 12 final codes categorized under 3 subcategories were integrated into 2 core categories.

Table 4

Classification of Core Categories, Subcategories, and Indicators for the Content Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Cultural Awareness and Knowledge	2	Multicultural Content - Multicultural Literacy	8
2	Intercultural Skills and Abilities	1	Cultural Intelligence	4

C. Learning Activities Element

Step One: Initial Coding

During the open coding phase, 16 initial codes were identified. After reviewing and eliminating duplicate codes, 8 codes were removed, leaving 8 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Learning Activities" element. The purpose of this stage was to establish relationships among the generated criteria.

Table 5

Results of Subcategory Classification for the Learning Activities Element

Criterion	Subcategory	Code
[N1-4] Group projects requiring student collaboration and participation		
[N10-5] Encouraging students to join multicultural workgroups		
[N4-5] Utilizing collaborative activities to enhance intercultural skills, such as effective communication, conflict resolution, and mutual understanding	Collaborative Activities	1
[N3-6] Interaction and cooperation among students from different cultures		
[N8-5] Exploring cultural issues such as discrimination, stereotypes, and inequalities		
[N14-4] Gaining a better understanding of different cultures and engaging in cultural exchange		

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[N7-5] Practicing intercultural skills such as respecting differences, effective communication, and resolving cultural conflicts [N13-5] Familiarizing students with diverse cultural perspectives and experiences	Multicultural Activities	2

Step Three: Selective Coding

Table below presents the results of selective coding, where 8 final codes categorized under 2 subcategories were integrated into 1 core category.

Table 6

Classification of Core Category, Subcategories, and Indicators for the Learning Activities Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Intercultural Interaction and Collaboration	2	Collaborative Activities - Multicultural Activities	8

D. Teaching-Learning Strategies Element

Step One: Initial Coding

During the open coding phase, 27 initial codes were identified. After reviewing and eliminating duplicate codes, 15 codes were removed, leaving 12 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Teaching-Learning Strategies" element. The purpose of this stage was to establish relationships among the generated criteria.

Table 7

Results of Subcategory Classification for the Teaching-Learning Strategies Element

Criterion	Subcategory	Code
[N1-5] Helping students develop intercultural abilities [N14-5] Encouraging students to interact with individuals from different cultures and resolve cultural conflicts [N4-6] Reflecting on and analyzing intercultural experiences to improve students' skills [N15-7] Encouraging students to think critically about cultural and social issues	Multicultural Skills	1
[N11-6] Allowing the use of various teaching methods for students with different skill levels [N12-6] Enhancing teaching methods based on students' diverse needs and conditions [N12-7] Preparing teachers to handle unexpected situations and changes in the learning environment [N13-7] Strategies for quickly adapting to new conditions, such as changes in technology access or specific student needs	Flexible Teaching	2
[N1-6] Special training for teachers to manage cultural differences among students [N3-8] Guides and resources to assist teachers in addressing challenges related to teaching in multicultural environments [N15-6] Activities and exercises to help teachers develop intercultural communication skills [N10-7] Guides and resources to help teachers address challenges related to teaching in multicultural environments	Multicultural Teachers	3

Step Three: Selective Coding

Table below presents the results of selective coding, where 12 final codes categorized under 3 subcategories were integrated into 2 core categories.

Table 8

Classification of Core Categories, Subcategories, and Indicators for the Teaching-Learning Strategies Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Development of Intercultural Skills and Abilities	2	Multicultural Skills - Multicultural Teachers	8
2	Adaptability and Flexibility in Teaching	1	Flexible Teaching	4

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E. Space Element

Step One: Initial Coding

During the open coding phase, 16 initial codes were identified. After reviewing and eliminating duplicate codes, 8 codes were removed, leaving 8 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Space" element. The purpose of this stage was to establish relationships among the generated criteria.

Table 9

Results of Subcategory Classification for the Space Element

Criterion	Subcategory	Code
[N15-8] Providing students with opportunities to use virtual spaces to interact with students and instructors from different geographic locations		
[N16-6] Utilizing advanced technologies to create diverse virtual educational spaces and simulate various cultural settings		
[N6-7] Enhancing global skills and intercultural understanding through diverse educational experiences	Spatial Diversity with Fractal Characteristics	1
[N13-8] Allowing students to benefit from multicultural and international educational resources		
[N12-8] Incorporating elements from various cultures to help students familiarize themselves with different cultural contexts		
[N1-7] Designing spaces that represent different cultures and promote intercultural interactions		
[N2-8] Helping students develop cultural awareness and a deeper understanding of diverse cultures	Intercultural Space	2
[N3-9] Using tools and platforms that enable students to access and engage with global cultural resources		

Step Three: Selective Coding

Table below presents the results of selective coding, where 8 final codes categorized under 2 subcategories were integrated into 1 core category.

Table 10

Classification of Core Category, Subcategories, and Indicators for the Space Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Spatial Diversity and Intercultural Interaction	2	Spatial Diversity with Fractal Characteristics - Intercultural Space	8

F. Time Element

Step One: Initial Coding

During the open coding phase, 16 initial codes were identified. After reviewing and eliminating duplicate codes, 8 codes were removed, leaving 8 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Time" element. The purpose of this stage was to establish relationships among the generated criteria.

Table 11

Results of Subcategory Classification for the Time Element

Criterion	Subcategory	Code
[N2-9] Students' access to educational materials at any convenient time		
[N16-7] Flexibility in scheduling time for assignments and educational activities		
[N13-9] Adjusting the necessary time for activities based on individual pace and abilities	Diverse Scheduling	1
[N14-7] Time adaptability to students' different needs and conditions		
[N5-9] Scheduling educational sessions to allow students adequate time to understand concepts and skills		
[N6-8] Providing students with time for rest and review of educational materials		
[N8-9] Adjusting instructional time for students who require additional time for comprehension	Instructional Time Suitability	2
[N10-9] Allocating more time to challenging topics to encourage student interaction and inquiry		

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Step Three: Selective Coding

Table below presents the results of selective coding, where 8 final codes categorized under 2 subcategories were integrated into 1 core category.

Table 12

Classification of Core Category, Subcategories, and Indicators for the Time Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Flexibility in Educational Timing	2	Diverse Scheduling - Instructional Time Suitability	8

G. Grouping Element

Step One: Initial Coding

During the open coding phase, 16 initial codes were identified. After reviewing and eliminating duplicate codes, 8 codes were removed, leaving 8 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Grouping" element. The purpose of this stage was to establish relationships among the generated criteria.

Table 13

Results of Subcategory Classification for the Grouping Element

Criterion	Subcategory	Code
[N9-9] Guidelines for forming multicultural teams to ensure participation of students from diverse cultural backgrounds in educational groups		
[N10-10] Activities and projects requiring effective collaboration among team members from different cultures		
[N4-10] Activities designed to encourage students to learn about and accept cultural differences within educational teams	Multicultural Teams	1
[N11-9] Helping students identify and manage challenges arising from cultural differences in multicultural teams		
[N6-9] Providing resources and tools to help students address specific challenges of working in multicultural groups		
[N13-10] Encouraging students to engage in cultural exchange and learn from one another in multicultural groups		
[N15-10] Offering students opportunities in multicultural groups to receive feedback and improve intercultural skills	Multicultural Group Development	2
[N16-8] Helping students gain a deeper understanding of their group members' cultures and fostering mutual respect		

Step Three: Selective Coding

Table below presents the results of selective coding, where 8 final codes categorized under 2 subcategories were integrated into 1 core category.

Table 14

Classification of Core Category, Subcategories, and Indicators for the Grouping Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Collaboration and Enhancement of Intercultural Interactions	2	Multicultural Teams - Multicultural Group Development	8

H. Educational Materials Element

Step One: Initial Coding

During the open coding phase, 28 initial codes were identified. After reviewing and eliminating duplicate codes, 16 codes were removed, leaving 12 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Educational Materials" element. The

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purpose of this stage was to establish relationships among the generated criteria.

Table 15

Results of Subcategory Classification for the Educational Materials Element

Criterion	Subcategory	Code
[N1-10] Introducing students to the history, art, and literature of different cultures		
[N1-11] Addressing intercultural topics such as cultural differences, historical intercultural interactions, and social issues related to multiculturalism		
[N2-11] In-depth exploration of cultures, customs, and beliefs	Multicultural Knowledge	1
[N2-12] Contemporary content for students to better understand current global cultural and societal issues		
[N3-12] Providing resources from various academic and cultural domains to promote diversity		
[N14-10] Utilizing diverse educational resources, including written texts, videos, podcasts, and digital materials, to accommodate different learning styles		
[N12-11] Ensuring variation in format and types of resources to enhance comprehension and engagement	Diverse Resources	2
[N16-10] Providing educational materials in multiple languages for better accessibility		
[N6-10] Implementing programs for continuous updating and enhancement of software and hardware infrastructure		
[N8-11] Using Learning Management Systems (LMS) to ensure necessary security features for protecting student and teacher data		
[N15-11] Implementing appropriate hardware infrastructure, such as servers, storage devices, and high-speed networks, for delivering educational content	Software and Hardware Infrastructure	3
[N16-9] Continuous improvements in technology to optimize students' learning experiences		

Step Three: Selective Coding

Table below presents the results of selective coding, where 12 final codes categorized under 3 subcategories were integrated into 2 core categories.

Table 16

Classification of Core Categories, Subcategories, and Indicators for the Educational Materials Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Educational Content and Resource Diversity	2	Multicultural Knowledge - Diverse Resources	8
2	Technical and Infrastructure Support	1	Software and Hardware Infrastructure	4

I. Evaluation Element

Step One: Initial Coding

During the open coding phase, 30 initial codes were identified. After reviewing and eliminating duplicate codes, 18 codes were removed, leaving 12 final codes categorized under subcategories.

Step Two: Axial Coding

Table below presents the results of subcategory classification for the "Evaluation" element. The purpose of this stage was to establish relationships among the generated criteria.

Table 17

Results of Subcategory Classification for the Evaluation Element

Criterion	Subcategory	Code
[N1-12] Assessing students' ability in analysis, critical thinking, and application of knowledge in real-world situations		
[N1-13] Providing qualitative evaluation feedback to help students identify strengths and weaknesses		
[N3-14] Utilizing diverse qualitative evaluation methods such as projects, portfolios, and presentations to assess student performance	Qualitative Evaluation	1
[N16-12] Allowing students to improve the learning process through qualitative feedback		
[N2-13] Using multiple-choice, true/false, and short-answer tests to measure students' understanding and knowledge		

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[N4-13] Establishing specific and measurable criteria for quantitative student assessment		
[N9-12] Using quantitative evaluation results as a basis for providing academic guidance and counseling	Quantitative Evaluation	2
[N11-12] Applying statistical analyses to identify strengths and weaknesses in student learning and improve the educational process		
[N5-12] Designing evaluations to ensure that cultural differences do not affect final outcomes and to promote educational equity		
[N9-13] Helping students demonstrate their knowledge and understanding of multicultural issues through evaluation		
[N8-12] Including activities and questions that assess students' ability to interact and collaborate with individuals from different cultures	Multicultural Evaluation	3
[N14-12] Adjusting evaluation tools to prevent cultural bias and ensure equal opportunities for all students to succeed		

Step Three: Selective Coding

Table below presents the results of selective coding, where 12 final codes categorized under 3 subcategories were integrated into 2 core categories.

Table 18

Classification of Core Categories, Subcategories, and Indicators for the Evaluation Element

Code	Core Category	Number of Subcategories	Subcategory	Number of Indicators
1	Assessment and Evaluation Methods	2	Qualitative Evaluation - Quantitative Evaluation	8
2	Cultural Sensitivity and Adaptability	1	Multicultural Evaluation	4

A descriptive analysis of the study participants revealed that 181 participants were male (72.40%), while 69 were female (27.60%). Additionally, 42 participants were single (16.80%), while 208 were married (83.20%). Regarding age distribution, 19 participants were aged 30 years or younger (7.60%), 73 participants were between 31 and 40 years old (29.20%), 88 participants were between 41 and 50 years old (35.20%), and 70 participants (28%) were older than 50 years.

In terms of educational level, 22 participants held a bachelor's degree (8.80%), 96 participants held a master's degree (38.40%), 63 were doctoral students (25.20%), and 69 participants (27.60%) held a doctoral degree. Concerning work experience, 21 participants had 5 years or less (8.40%), 49 participants had between 6 and 10 years (19.60%), 63 participants had between 11 and 15 years (25.20%), 61 participants had between 16 and 20 years (24.40%), and 56 participants (22.40%) had more than 20 years of experience.

To determine whether the sample size and variable relationships were appropriate for factor analysis, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were conducted. The KMO index assesses the adequacy of sampling by examining the magnitude of partial correlations among variables. The KMO values for the elements of objective, content, learning activities, teaching-learning strategies, space, time, grouping, educational materials, and evaluation were 0.884, 0.827, 0.828, 0.820, 0.826, 0.762, 0.812, 0.833, and 0.832, respectively, while Bartlett's test of sphericity yielded a significance level of 0.0009. These results confirmed the adequacy of the sampling, justifying the use of factor analysis based on the correlation matrix under study.

The extracted factors and their explained variance percentages were analyzed. For the objective element, three investigated factors had eigenvalues greater than 17, collectively accounting for approximately 58% of the total variance. The eigenvalues for the first, second, and third factors were 20.87, 20.83, and 17, respectively.

For the content element, three investigated factors had eigenvalues greater than 17, explaining approximately 60% of the total variance. The eigenvalues for the first, second, and third factors were 22.10, 21.15, and 17.20, respectively.

For the learning activities element, two investigated factors had eigenvalues greater than 25, explaining approximately 57% of the total variance. The eigenvalues for the first and second factors were 31.35 and 25.94, respectively.

For the teaching-learning strategies element, three investigated factors had eigenvalues greater than 15, explaining approximately 58% of the total variance. The eigenvalues for the first, second, and third factors were 21.57, 21.17, and 15.66, respectively.

For the space element, two investigated factors had eigenvalues greater than 24, explaining approximately 57% of the total variance. The eigenvalues for the first and second factors were 32.77 and 24.77, respectively.

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For the time element, two investigated factors had eigenvalues greater than 24, explaining approximately 56% of the total variance. The eigenvalues for the first and second factors were 32.15 and 24.47, respectively.

For the grouping element, two investigated factors had eigenvalues greater than 25, explaining approximately 56% of the total variance. The eigenvalues for the first and second factors were 30.46 and 25.80, respectively.

For the educational materials element, three investigated factors had eigenvalues greater than 17, explaining approximately 57% of the total variance. The eigenvalues for the first, second, and third factors were 20.65, 19.90, and 17.44, respectively.

For the evaluation element, three investigated factors had eigenvalues greater than 17, explaining approximately 58% of the total variance. The eigenvalues for the first, second, and third factors were 20.74, 20.45, and 17, respectively.

A second-order confirmatory factor analysis was used to examine the research model, and the results are presented in Table below.

Table 19

Path Coefficients and Significance Levels of the Research Model

Path Between Variables	Path Coefficient	t-Statistic	p-value	Result
Objective > Understanding Multicultural Concepts	0.830	37.537	0.0009	Significant
Objective > Educational Equity	0.839	35.530	0.0009	Significant
Objective > Cultural Cohesion	0.726	18.804	0.0009	Significant
Content > Multicultural Literacy	0.802	25.170	0.0009	Significant
Content > Multicultural Content	0.595	9.582	0.0009	Significant
Content > Cultural Intelligence	0.805	31.829	0.0009	Significant
Learning Activities > Collaborative Activities	0.900	72.280	0.0009	Significant
Learning Activities > Multicultural Activities	0.775	23.077	0.0009	Significant
Teaching-Learning Strategies > Flexible Teaching	0.752	17.355	0.0009	Significant
Teaching-Learning Strategies > Multicultural Teachers	0.641	11.359	0.0009	Significant
Teaching-Learning Strategies > Multicultural Skills	0.761	17.157	0.0009	Significant
Space > Spatial Diversity with Fractal Characteristics	0.888	60.194	0.0009	Significant
Space > Intercultural Space	0.808	30.991	0.0009	Significant
Time > Instructional Time Suitability	0.932	37.310	0.0009	Significant
Time > Diverse Scheduling	0.524	4.580	0.0009	Significant
Grouping > Multicultural Group Development	0.782	22.505	0.0009	Significant
Grouping > Multicultural Teams	0.890	61.393	0.0009	Significant
Educational Materials > Multicultural Knowledge	0.659	10.878	0.0009	Significant
Educational Materials > Software and Hardware Infrastructure	0.787	26.203	0.0009	Significant
Educational Materials > Diverse Resources	0.809	26.416	0.0009	Significant
Evaluation > Multicultural Evaluation	0.710	14.915	0.0009	Significant
Evaluation > Quantitative Evaluation	0.739	19.135	0.0009	Significant
Evaluation > Qualitative Evaluation	0.826	34.622	0.0009	Significant

From the participants' perspective, the results indicate that the Fractal Model of Virtual Curriculum with an Intercultural Approach in the Islamic Azad University branches of Mazandaran consists of 23 components. Figures (2) and (3) illustrate the research model in terms of standardized coefficients and significance levels.

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Figure 1

Main Model with Standardized Coefficients

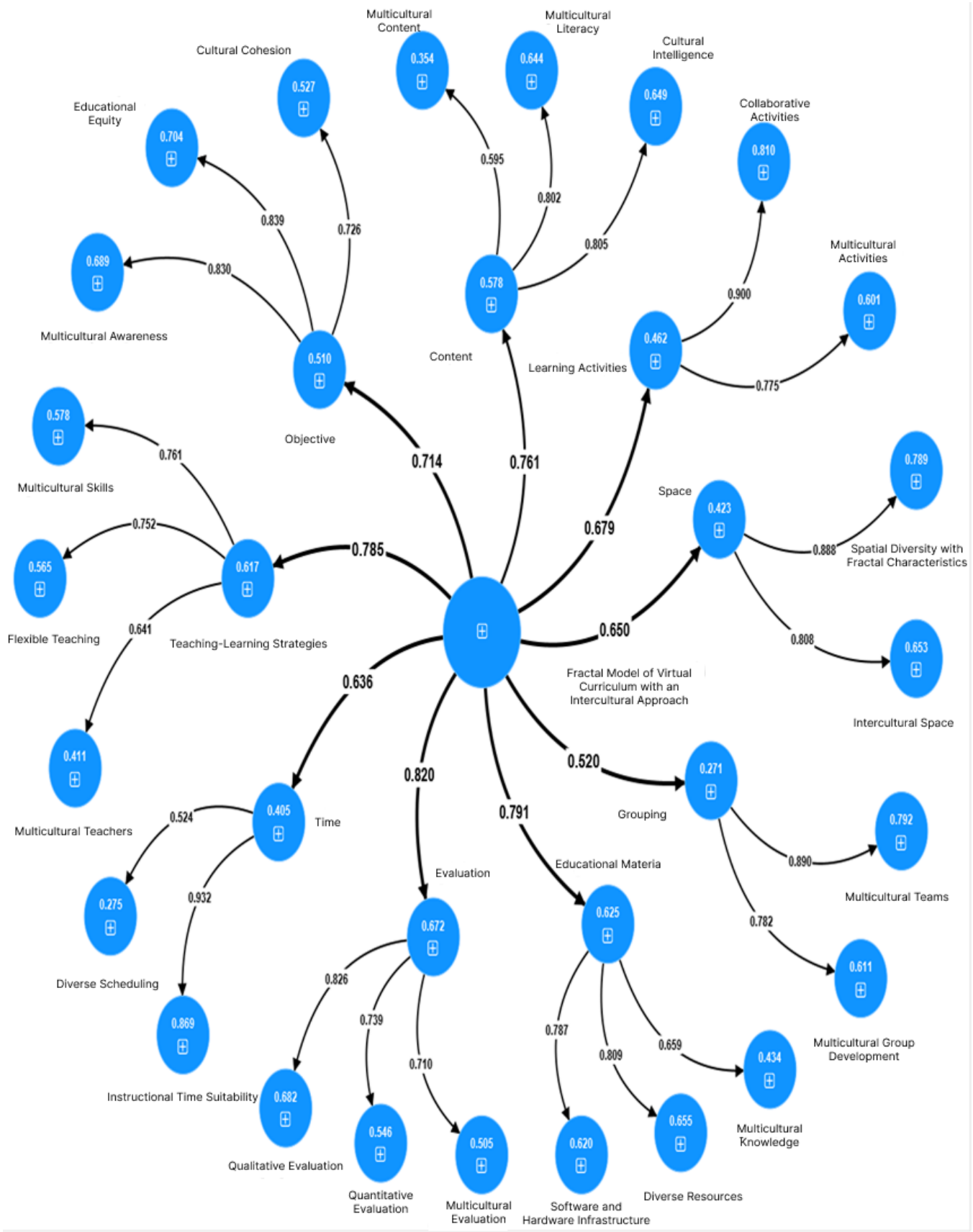

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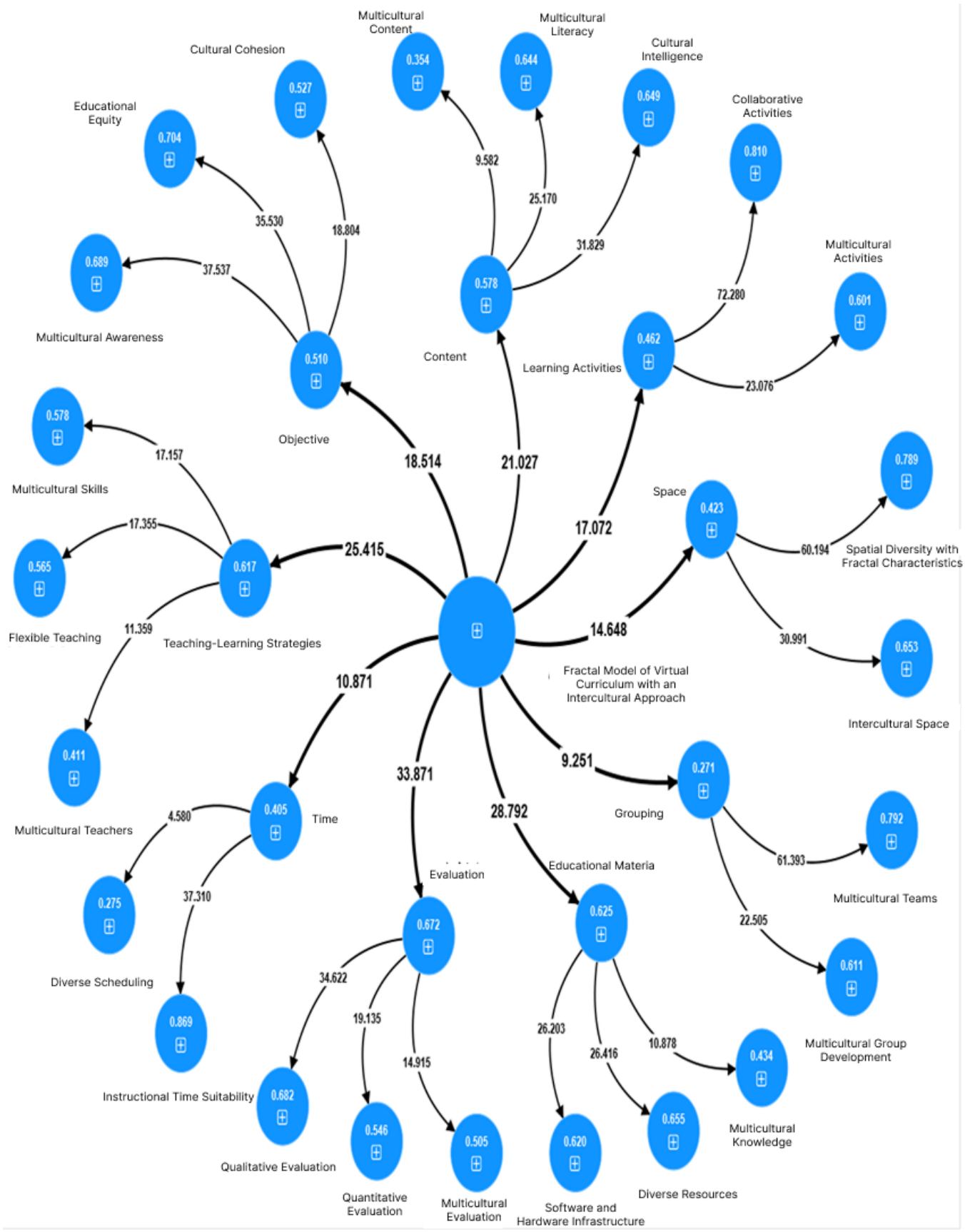
Figure 2

Main Model with Significance of Coefficients



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The data obtained from the field study were analyzed using SMART-PLS software, yielding the following results.

Table 20

Path Coefficients and Significance Levels of the Research Model

Path	Standardized Coefficients	t-Values	p-value	Result
Fractal Model of Virtual Curriculum with an Intercultural Approach > Evaluation	0.820	33.871	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Teaching-Learning Strategies	0.785	25.415	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Time	0.636	10.871	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Space	0.650	14.648	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Learning Activities	0.679	17.072	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Content	0.761	21.027	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Educational Materials	0.791	28.792	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Objective	0.714	18.514	0.0009	Significant
Fractal Model of Virtual Curriculum with an Intercultural Approach > Grouping	0.520	9.251	0.0009	Significant

The results in the table confirm the explanatory power of the nine elements in the research model.

4. Discussion and Conclusion

The findings of the present study confirm the effectiveness and structural validity of the Fractal Model of Virtual Curriculum with an Intercultural Approach in the context of higher education. The model, developed for the Islamic Azad University branches of Mazandaran, comprises nine essential elements: objectives, content, learning activities, teaching-learning strategies, space, time, grouping, educational materials, and evaluation, with 23 subcomponents. The structural model analysis through SMART-PLS revealed significant path coefficients for all elements, demonstrating the robustness of the model in capturing key dimensions necessary for a culturally responsive virtual curriculum.

A crucial finding was the significance of the objective element, particularly regarding multicultural awareness, educational equity, and cultural cohesion. The strong positive relationship between objectives and multicultural awareness ($\beta = 0.830$, $p = 0.0009$) and educational equity ($\beta = 0.839$, $p = 0.0009$) suggests that an intercultural approach within a virtual curriculum must prioritize fostering inclusivity and social justice. This aligns with previous research indicating that multicultural education frameworks enhance students' ability to engage with diverse perspectives and reduce biases in digital learning spaces (Banks, 2019). Moreover, scholars have emphasized that equitable access to resources in virtual learning environments mitigates disparities in academic achievement (Gay, 2020), reinforcing the necessity of prioritizing equity in curriculum design.

The content element demonstrated significant relationships with multicultural literacy ($\beta = 0.802$, $p = 0.0009$), multicultural content ($\beta = 0.595$, $p = 0.0009$), and cultural intelligence ($\beta = 0.805$, $p = 0.0009$). These findings suggest that curriculum designers must integrate diverse educational materials that reflect a wide range of cultural narratives. This outcome resonates with prior studies that found multicultural curricula improve students' cognitive flexibility and cultural adaptability (Bozorgi & Goli Tavana, 2024). Additionally, research on digital learning environments has highlighted the role of culturally embedded content in enhancing engagement and retention among learners from diverse backgrounds (Afzali et al., 2023). The strong association between cultural intelligence and content design further supports arguments that digital learning should incorporate interactive and cross-cultural case studies to maximize learning outcomes (Mazaheri Forushani, 2024).

The study also demonstrated the centrality of learning activities, with collaborative activities ($\beta = 0.900$, $p = 0.0009$) and multicultural activities ($\beta = 0.775$, $p = 0.0009$) being key contributors. These findings align with research emphasizing the importance of peer collaboration in intercultural education (Enayati Novin-Far & Farhad, 2020). Scholars have long established that learning in multicultural teams fosters intercultural competence and enhances students' ability to function in globalized professional settings (Afzali et al., 2023; De Hei et al., 2019; Khoshrovi, 2022). Furthermore, digital pedagogies that facilitate cross-

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cultural dialogues, group discussions, and international collaboration have been shown to significantly enhance students' engagement and cultural empathy (Bagherzadeh Vashki Zaman & Alireza, 2021; Shirvani et al., 2021).

In the realm of teaching-learning strategies, the study confirmed that flexible teaching methods (β = 0.752, p = 0.0009), multicultural teaching approaches (β = 0.641, p = 0.0009), and multicultural skills training (β = 0.761, p = 0.0009) are essential. These results are consistent with prior studies emphasizing that virtual instructors must be equipped with pedagogical flexibility and cultural responsiveness (Mostafaei & Hosseini, 2021; Warren et al., 2021). Additionally, research on intercultural education indicates that teachers who undergo multicultural training are more effective in engaging students from diverse linguistic and cultural backgrounds (Bozorgi & Goli Tavana, 2024; Mazaheri Forushani, 2024). The importance of multicultural teaching strategies has also been recognized in frameworks of inclusive education, where instructors are expected to adopt adaptive and learner-centered methodologies to accommodate varying cultural expectations in online learning (Amrollah & Azadi Ahmadabadi, 2021; Arruzza & Chau, 2021; Bagherzadeh Vashki Zaman & Alireza, 2021).

The space element, which includes spatial diversity with fractal characteristics (β = 0.888, p = 0.0009) and intercultural space (β = 0.808, p = 0.0009), reinforces the idea that virtual learning environments must be designed to simulate diverse cultural settings. This finding is in agreement with research that supports the creation of culturally dynamic digital spaces, where students can interact with global perspectives (Shahbazi et al., 2020a, 2020b). Additionally, prior studies have argued that adaptive virtual spaces enhance immersion and engagement by allowing students to explore different cultural contexts in an interactive manner (Shahbazi, 2020; Shahbazi et al., 2020a, 2020b).

Regarding the time element, the findings suggest that instructional time suitability (β = 0.932, p = 0.0009) and diverse scheduling (β = 0.524, p = 0.0009) are critical for ensuring accessibility in online education. These results align with research indicating that flexible scheduling is particularly important for multicultural and international learners. Scholars have pointed out that time-zone differences, individual learning speeds, and external obligations necessitate adaptable scheduling mechanisms in virtual curricula (Keramati, 2020; Sabouri et al., 2020; Shahab Lavasani et al., 2020).

The grouping element emerged as another significant factor, with multicultural teams (β = 0.890, p = 0.0009) and multicultural group development (β = 0.782, p = 0.0009) playing a central role. Previous research highlights that group-based learning in diverse teams significantly enhances problem-solving and intercultural collaboration (Bagherzadeh Vashki Zaman & Alireza, 2021; Hamedinasab Sadegh et al., 2021; Mostafaei & Hosseini, 2021). Additionally, studies confirm that intercultural teamwork in virtual classrooms fosters cross-cultural understanding, enhances negotiation skills, and reduces ethnocentrism (De Hei et al., 2019; Ghanbari et al., 2019; Mostafazadeh et al., 2019; Saberi & Mozhgan, 2019; Shamshirgaran & Afkari Fereshteh, 2019).

In terms of educational materials, the study found significant correlations with multicultural knowledge (β = 0.659, p = 0.0009), software and hardware infrastructure (β = 0.787, p = 0.0009), and diverse resources (β = 0.809, p = 0.0009). This reinforces the necessity of technological infrastructure that supports multilingual and culturally rich content. Prior research has underscored the importance of educational technology in expanding access to culturally diverse materials and enhancing digital inclusivity (Mazaheri Forushani, 2024; Shahbazi et al., 2020b).

Finally, the evaluation element, consisting of multicultural evaluation (β = 0.710, p = 0.0009), quantitative evaluation (β = 0.739, p = 0.0009), and qualitative evaluation (β = 0.826, p = 0.0009), suggests that assessments must be designed to reflect cultural inclusivity. This supports previous arguments that traditional evaluation methods may disadvantage students from diverse backgrounds and that culturally responsive assessments improve learning outcomes. Research has also demonstrated that qualitative and multicultural assessments enhance students' ability to apply knowledge in diverse real-world settings (Afzali et al., 2023; Enayati Novin-Far & Farhad, 2020; Hamedinasab Sadegh et al., 2021; Keramati, 2020; Saberi & Mozhgan, 2019; Shamshirgaran & Afkari Fereshteh, 2019).

The study is limited in its scope as it focuses exclusively on Islamic Azad University branches in Mazandaran, which may affect the generalizability of findings to other institutions or cultural contexts. Additionally, while the research employed SMART-PLS for model validation, future studies may benefit from longitudinal assessments to determine the sustained effectiveness of the proposed curriculum model. Another limitation is the reliance on self-reported data, which may introduce bias or social desirability effects in participants' responses.

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Future research should explore cross-institutional studies to validate the applicability of the fractal model across diverse educational settings. Additionally, investigating the long-term impact of intercultural virtual curricula on students' professional competencies and career success would be valuable. Research should also focus on developing AI-driven adaptive learning environments that further enhance multicultural engagement in virtual education.

Educational institutions should prioritize faculty training programs in multicultural digital pedagogy to enhance teaching effectiveness in virtual environments. Universities should also invest in technological infrastructure that enables adaptive and interactive multicultural learning experiences. Lastly, policymakers must ensure that curricula remain responsive to cultural diversity by incorporating inclusive assessment methods and content that reflects global perspectives.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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